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THE V.A.-BIONIC LASER CANE.

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equipped. I feel that appropriately designed tactile maps or images, perhaps even including verbal instructions or descriptions, is an excellent way to provide the blind traveller with environmental information which will enhance his mobility.

In closing I would like to inform you of some current developments in aids which have been marketed as mobility and orientation devices for the blind. Silva has developed and is offering for sale a powerful compass which is the size of a braille pocket watch and will have a great deal of utility for orienting the blind in environments suitable for compasses. A recently established corporation known as Sensory Aids Corp. has production engineered a sound source football for the blind known as the AUD-A-BALL, and is offering the ball for sale to agencies and centers for the blind. MIT has long since established the usefulness of sound source balls which can be used as training devices and at play for blind children and adults. A great deal of original effort and investigation has been done through student theses activities on sound source balls for the blind in the Mechanical Engineering Dept. of M.I.T.

I do not want to leave you with the impression that tactile maps, electronic mobility devices or other aids can individually solve the mobility problems of the blind, but instead, I mean to convey that the mobility and orientation problem is a complex one and that no unique solution exists to overcome it. Tactile displays will help, mobility devices will help, and training for all ages at any level of sophistication is most important.

THE V. A. - BIONIC LASER CANE

by Eugene F. Murphy, Ph.D., Chief
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Editor's Note: Dr. Murphy delivered this paper to the Mobility Interest Group of the American Association of Workers for the Blind, Richmond, Virginia, July 19, 1971.

The VA-Bionic Laser Cane for the Blind is currently available in ten copies which are about to be given a preliminary evaluation at Hines and Palo Alto VA Hospitals. Five weeks of training and tests of eight selected blinded veterans will be followed by approximately nine months of hometown comparative use of the laser and the conventional canes by these veterans. The evaluation plan has been developed with advice of a panel under the chairmanship of Dr. Patrick Nye of the Subcommittee on Sensory Aids of the National Research Council. The laser cane is only one of a number of attempts to improve the mobility of the blind which have been developed, evaluated, or both under the sponsorship of the Veterans Administration.

The laser cane represents the culmination of an interest for more than two decades in problems of mobility for the blind on the part of the Veterans Administration. This work has been summarized in an article by Benjamin (1) and details have been reported in Bionic Instruments progress reports (2, 3), companion reports by Tracor (4) on the evaluation of an earlier Bionic device, and related papers by Reilly et al. (5) on the evaluation of early models of the Kay Ultrasonic Torch.

The Long Cane News
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During World War II the wartime Office of Scientific Research and Development stimulated creation of the National Research Council's Committee on Sensory Devices, later supported by the Veterans Administration. As a part of its efforts on mobility, there were three attempts at ultrasonic object detectors under Brush Development, Hoover, and Stromberg-Carlson. Likewise the Army supported the development of the Signal Corps mobility aid designed by Lawrence Cranberg using optical triangulation by using visible light. All of these received some preliminary trials at Haskins Laboratories (6).

About 1950 and following a production-engineered model of the Army Signal Corps device, built by RCA, was tested in multiple copies by Prof. Thomas A. Benham of Haverford College, in a field trial involving ultimately about 60 people (7). This aid appeared to be useful for the detection of objects and obstacles straight ahead. If it were tilted downward, it could measure the slant height to the ground and thus detect curbs by the sudden increase in the distance to the ground. There were difficulties, however, because of the vertical oscillation of the body of the user during walking, the swinging of his arms, and the distraction caused by a constant signal which changed rhythmically during walking and yet whose sudden change was supposed to detect a curb. Many blind users objected to the constant presence of the signal. Professor Benham, in a paper presented at the 1953 annual convention of the American Association for the Advancement of Science (8), summarized the results of the evaluation and gave recommendations for improved models.

The Veterans Administration then embarked in a long period of development to try to achieve these goals. Work was done first under a VA contract with Haverford College which in turn used the then Bio-physical Instruments, later organized as Biophysical Electronics and as Bionic Instruments, as a sub-contractor. Later a direct contract was made with Bionic Instruments. Out of this project eventually arose the Bionic Instruments G-5 object detector, somewhat like a lunchbox. Though it made no pretense to step-down detection, it appeared quite reliable at detecting objects ahead of the user when carried at his side. This device used flashes of light from an EG&G flashlamp to perform detection of obstacles by optical triangulation, a principle which after much study by Bionic Instruments seems to remain the most versatile method.

The G-5 device was evaluated in ten copies by Tracor of Austin, Texas, with the cooperation of Professor Worchel of the University of Texas, a psychologist long interested in mobility problems of the blind (9). It became apparent that subjects were happy to be able to explore and identify objects beyond arm's length. This new ability tended to enrich their knowledge of environment. Some congenitally blind subjects were particularly fascinated to discover, for example, that chandeliers hung downward from the ceiling which they had always presumed was flat and featureless. Though this richer appreciation tended to slow their passage through an obstacle course or a busy street, nevertheless a retest of available subjects showed that, if urged to do so, they could move rapidly. By merely looking for openings without identification of the bordering obstacles, they could go through obstacle courses with the same speed and with no more errors than with the conventional cane or guide dog. Indeed, those subjects who claimed to travel unaided (but probably actually used the elbow of a sighted friend a good deal of the time) were able to go through the obstacle course with dramatically fewer errors than in a completely unaided condition.

Shortly afterward the gallium arsenide light emitters, about the size of a transistor case, became available. They were immediately used by Bionic Instruments to develop a flashlight-shaped object detector. Without a ranging feature, this was merely intended for limited local protection during travel on level and familiar ground while serving as a test vehicle for development of circuitry. Still later, in 1966, true gallium arsenide lasers operating at room temperature became available and were promptly used by Bionic to build a series of devices in cane configuration with three optical triangulation systems, culminating in the C-4 cane currently being tested. The goal was to keep the proven value of the long cane while supplementing the shortcomings.

THE C-4 CANE

In the C-4 cane, one of the laser beams of invisible infrared light shines upward so that its companion photocell, "looking" upward from a lower point on the cane shaft, can detect reflections from overhead obstacles which would otherwise strike the chest, head, or shoulders of the cane user. Protection is thus afforded against objects above the cane handle which normally can only be detected by echo location if the cane is used in the orthodox fashion with its tip on the ground. A second beam and its associated photocell project their detection area forward to give distant early warning of obstacles out to about 12', equivalent to an impracticably long mechanical cane and useful both to identify distant landmarks while crossing a street or parking lot and also to detect pedestrians or window shoppers without mechanically rapping their shins. The third beam points forward and downward to identify major discontinuities in the terrain such as the edge of a subway platform, a descending flight of stairs, or other major dropoffs. As yet, it is <u>not</u> sufficiently sensitive to detect ordinary small curbs, which still must be located by loss of mechanical contact in conventional long cane technique. It is hypothesized, however, that some blind users will be able to walk more confidently and in a more relaxed fashion if they have some assurance of warning against major hazards.

The Bionic Instruments designers assumed that the middle or forward looking beam would give the most frequent signals, so they provided a tactile stimulation consisting of a pin vibrating against the index finger of the hand holding the cane. This nonaudible signal normally would be detected only by the user. The other two signals typically occur much less frequently and are given by an audible tone from a small loudspeaker in the end of the crook in the cane handle. Overhead obstacles are signaled by a high-pitched tone, while major dropoffs are indicated by a low-pitched tone. Recently, the evaluating team has suggested that an intermediate tone might be desirable instead of or as a supplement to the tactile stimulation, so Bionic Instruments has modified the canes currently being tested to allow direct comparison of the usefulness of tactile and audible signals. Preliminary experience indicates that availability of <u>both</u> tactile and auditory signals is needed, e.g., noisy vs quiet locations, fingers numbed by cold or by gloves, etc.

The canes had already been modified so that the signals being given to the user by the three channels could be presented through a telemetering system (carried by the user and plugged into the same jack used for recharging the nickel cadmium batteries) conveyed to a small FM radio carried by a mobility instructor observing from a distance. It is

thus possible, for example, to detect the first point at which the signal is presented and thus to measure the reaction time and the distance travelled by the subject before he stops or otherwise shows that he has detected a hazard.

UNEXPECTED PROTECTION VS. "FALSE ALARMS"

It should be noted that a photocell responds in the same way, giving its characteristic output signal, whenever it detects laser light within its field of view and during the time it is "turned on" or "gated" to match the brief pulse of laser light. There are possibilities, as shown by a detailed study of the geometry of the beams and fields of view of the photocells, that one laser will cause a spot of invisible infrared light on a target within the field of view of another cell than the one with which that laser normally cooperates. Thus certain nearby objects may be detected if one is aware of the subtleties of the system, yet the inexperienced or untrained user may initially be bewildered by apparent false alarms. Advanced training in these possibilities should of course follow the conventional training in which the beams are stimulated in their normal functions. An instructor fully understanding these possibilities will realize that they provide useful information, not false alarms.

LASER SAFETY

The concept of a laser, of course, immediately causes concern about safety aspects. There has been so much discussion of high-powered lasers for the cutting of metals and the welding of retinas for retinal detachment that the general public is concerned about laser safety. There are increasing number of attempts to develop codes and legal regulations. Bionic Instruments has duly registered as a laser device manufacturer in the state of Pennyslvania. The author has attended the Second International Laser Safety Conference at the University of Cincinnati in 1969 and the Conference on Safety of Lasers, Microwaves, and Ultraviolet Radiation, also conducted by the University of Cincinnati, in 1971. He has talked with a great variety of experts in government, universities, research institutions, and industry. The consensus has been overwhelmingly reassuring. The laser and drive circuit used by Bionic have been tested by the Air Force (10) and complete laser canes have been tested by two units of the Army as well as by the University of Cincinnati Laser Laboratory (11) with the cooperation of the Medical College of Virginia. The testing program has included both physical measurements of strength and divergence of the beam and prolonged exposure in monkey eyes. No damage has been found in the biological tests. The physical tests typically indicate intensities slightly above a threshold which has been tentatively set on a very conservative basis but well below the calculated equivalent of the threshold at which any biological damage has ever been found with other, far more powerful and more "coherent" lasers of different types. A testing program has also been carried out by the United States Public Health Service on an actual laser cane, but the formal report is not yet available. Informal discussions with those conducting all these tests indicate no cause for alarm with the VA-Bionic laser cane.

EVALUATION

As a first step toward evaluation it seemed desirable to gain the opinions of skilled mobility therapists. The next step was to develop new teaching techniques based upon modifications of conventional long cane therapy. Then the goal is to have selected blind persons with above-average mobility skills receive special training and experiment with the cane. It is recognized that there are so many variables in the field that one cannot expect to have a really good evaluation with only 10 C-4 canes. On the other hand, there is the dilemma that one does not wish to build large numbers of additional copies if the present cane should seem hopeless or if obvious improvements could be made based upon a limited evaluation. An early model cane, C-3, was shown relatively briefly in periods of a few hours to a few days to about 50 mobility experts in the New York, Boston, and Chicago areas. Beneficial suggestions received from this exposure were included during the design of the C-4 cane. The C-4 cane was then presented for periods of weeks or months at a time to the staffs at Hines and Palo Alto VA Hospitals for preliminary trials by one mobility therapist functioning under a blindfold with supervision and instruction from a second mobility therapist. Because at that time the laser safety aspect seemed somewhat uncertain, the cane was used initially only on VA property.

With increasing confidence in all aspects of the cane, its use was gradually extended. Blind staff members were allowed to take the cane out on the adjoining streets for prolonged use in daily life. In addition, mobility therapists at other non-VA institutions were allowed to use the cane for periods of weeks or months with the goal of gaining greater insight into instructional methods and the use of the cane with a wider population. This included blind children at the Missouri School for the Blind and civilian blind individuals in other settings including Seeing Eye. Canes were loaned to the Western Michigan University, California State College, Los Angeles, and Florida programs for teaching mobility instructors.

To combine the insights gathered by the various mobility instructors during the preliminary use under a variety of circumstances, a meeting was convened at Hines VA Hospital in September 1970 under the auspices of the Subcommittee on Sensory Aids, Committee on Prosthetics Research and Development, National Research Council (12). There was general consensus that the forward-looking or middle beam was particularly valuable, although there was a somewhat variable opinion on the merits of the other two beams. There was some feeling that the upward looking beam should be tilted forward to indicate targets about 2' ahead of the tip of the cane when held at the "usual" 45° angle (which mobility experts had suggested as the design condition) rather than directly over the tip of the cane as had been requested based on earlier experience. Based upon the recommendations of the September 1970 meeting, small changes were made in the existing ten canes, and they were thoroughly checked over at the development laboratory. Five apiece were then distributed to Hines and Palo Alto VA Hospitals, with the concept of supplying four veterans at each center and keeping one cane as a spare.

As noted earlier, a protocol (13) for preliminary evaluation was developed by an NRC panel consisting of both engineers and experienced mobility therapists. The plan calls for recruitment at each center of eligible veterans with better-than-average mobility skills, intensive

evaluation of ability with conventional long cane techniques, training with the laser cane, and then evaluation on both obstacle courses and city routes of increasing traffic density during the month of August, 1971. The performance of each subject will be recorded with motion picture or video tape equipment. Each veteran will then take his cane home for continued routine use with follow-up by telephone contacts and visits by two mobility therapists. In a step relatively unusual in evaluation of prosthetic devices, each subject will later be asked to return to use of the conventional long cane for a period of weeks, then to make a comparison. It is hoped that the experience with the existing laser canes will contribute both numerical data and clinical impressions which will be useful in the development, prescription, and training programs for mobility devices in general.

One of the most important features of the evaluation is the development of prescription criteria. It is not enough to say that the cane is accepted or rejected by certain percentages of users. Rather it is necessary to discover the types of users for whom it is most appropriate. Long experience with prosthetic and sensory aids has shown that there is no single panacea suitable for all users. Instead, different types of devices may be useful for different individuals or even for the same individuals under different circumstances. Thus one needs an armamentarium of devices from which selection can be made. Appropriate interdisciplinary clinic teams such as Visual Impairment Service Teams may then be used to help the patient in the proper prescription of devices, in training, and in checking out his performance with the new device.

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REPORT ON LOW VISION AND MOBILITY

by Loyal E. Apple, Chief
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Editor's Note: Mr. Apple and his wife Marianne delivered a presentation on the subject of mobility training for persons with low vision to the A.A.W.B. Mobility Interest Group in Richmond, Virginia, July 20, 1971.

Low Vision is the greatest single unmet need in the field of Orientation and Mobility today. Those involved in Orientation and Mobility Services do not have answers on low vision. Yet sixty to seventy per cent of their case load is composed of persons who are legally blind, but have useful vision. We generally underestimate the potential of the

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